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Analyzing the Material "Fingerprint": The Relationship of Fundamental Frequency to Young's Modulus

The purpose of this project is to first, develop a mathematical relationship between the fundamental frequency of a material and its Young's modulus and second, construct an apparatus that can test "every day" material samples for their fundamental frequencies and then using other known physical measurements of the material, calculate the Young's modulus. A frame was constructed out of aluminum and a load cell taken from a digital kitchen scale was attached to it. Using locking pliers, both carbon steel wire and a rubber band were clamped across the frame and tested. Using an infrared photo-gate (resolution=1/1000 seconds), the frequency of the string when plucked was measured. Because steel is incredibly stiff, its change in length under the applied 14.7 Newton's was insignificant and therefore the accuracy of the existing photo-gate was not adequate to precisely measure the fundamental frequency. The rubber band acted the opposite, and stretched 240% of its original length. A frequency of 58 hertz was measured resulting in 111 PSI, only three PSI lower than the true tested Young's modulus of the rubber band: 115 PSI. There is still however a ± 9.5 PSI uncertainty and therefore the apparatus is only good for finding a range of relatively accurate Young's moduli. The significance of this project is that the relationship of frequency to Young's modulus is very sensitive and therefore it is only cost effective and feasible to test a materials Young's modulus by means of its frequency if it is not stiff and rigid.